SPC-12
Industrial Automation Computer

GENERAL AUTOMATION, INC.

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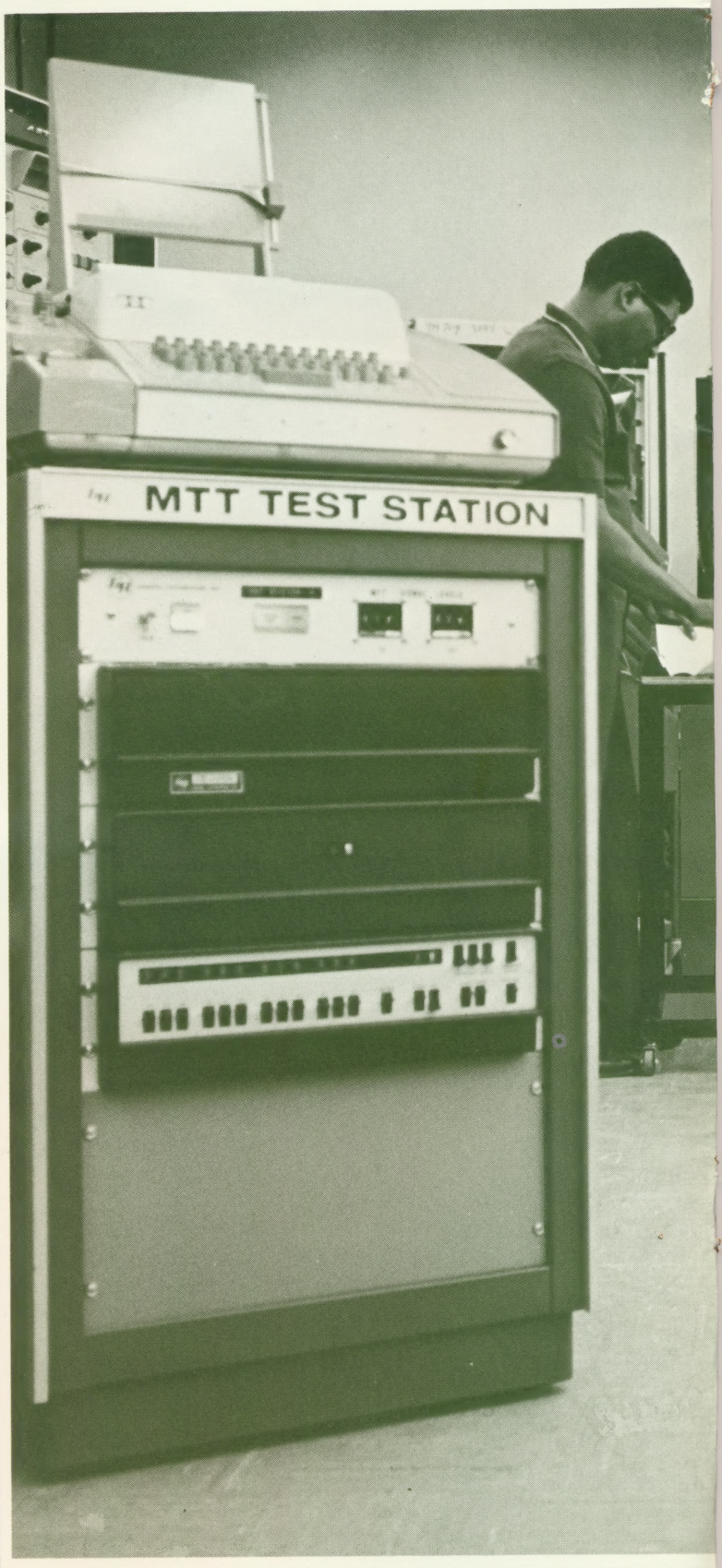

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INTRODUCTION

General Automation's SPC-12 computer is designed to provide industrial automation solutions. It will collect data, control machinery, monitor processes, control communications systems, test equipment, and perform a wide range of other automation functions in the industrial environment. GA's fourth generation computer technology enables industry to supply better products to more people at lower costs . . . through automation.

GA's SPC-12 Automation Computer is the industry's value leader in performance-versus-cost, system versatility, and programming simplicity. Its small size, low cost, high reliability and real-time features make the SPC-12 ideal for remote site, locally-dedicated control applications. The computer is designed to work with and on the same level as the industrial machinery, mechanisms, process instrumentation, sensors, communication networks, and data equipment it controls. The SPC-12 can increase your productivity and profits with a minimum initial investment and fast payback. With GA's product compatibility, applications experience, and specialized technical services, GA makes it easy and practical to automate.

The SPC-12 is equally versatile as an integral part of an automated machine tool, as it is controlling a production test unit. GA SPC-12 computers have been used to control traffic, test engines, set type, drill holes, make printed circuit boards, rivet airplane wings, monitor power generation systems, control nuclear reactors, switch communications systems, mix cement, count cars, manufacture electronic components, automate lab instruments, test computer peripherals, control displays, test automobiles and carburetors, move materials, and perform a variety of other industrial tasks. Time after time and in application after application, the SPC-12 has performed reliably, efficiently, and profitably.

General Automation is a TOTAL SOLUTION COMPANY; it realizes that powerful, high quality computers like the SPC-12 in themselves do not solve problems. Problems are solved with systems, and systems include computer hardware, applications software, and a wide range of automation services. Through GA, customers obtain from ONE SOURCE all or any part of the system elements required to solve an automation problem.

Real-time computer applications for the SPC-12 fall into four major classifications: Communications, Data Acquisition and Process Control, Instrumentation and Laboratory Automation, and Manufacturing Automation. Examples of these application areas are described on pages 2 and 3.

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APPLYING THE SPC-12 COMPUTER

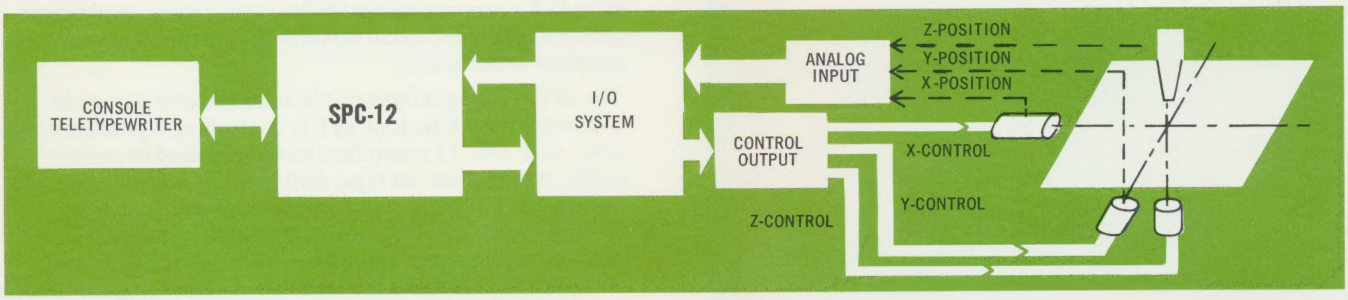
THE SPC-12 IN MANUFACTURING AUTOMATION

General Automation computers are designed to provide reliable automation solutions in the manufacturing environment. An example of manufacturing automation is an automatic three axis machine tool used in the winding of coils. This, and other types of numerical control machines are being used by major manufacturers to provide increased production and higher quality through greater accuracy and lower rejection rates.

The General Automation SPC-12 computer is the central control element of this three axis machine tool. The SPC-12 generates the sequence of control signals required to move the machine on its three axes as well as monitoring the machine's actual position to ensure the system's accuracy. In addition, displays showing both the system's parameters and any error conditions in the machine tool are available on demand.

In the full system, one SPC-12 computer controls a number of machine tools independently. Any of the several patterns stored in memory can be selected to run on any of the machines simultaneously.

Because of the SPC-12 Automation Computer, the production rate is significantly increased because hand work is practically eliminated and the rejection rate is reduced to nearly zero. Both of these factors substantially reduce the cost of the finished product. In addition, computer programming takes all of the tedious manipulation of the adjustments out of the hands of the operator. The total system, including the computer, the interfacing to the machine, and the application software, were all supplied by General Automation.

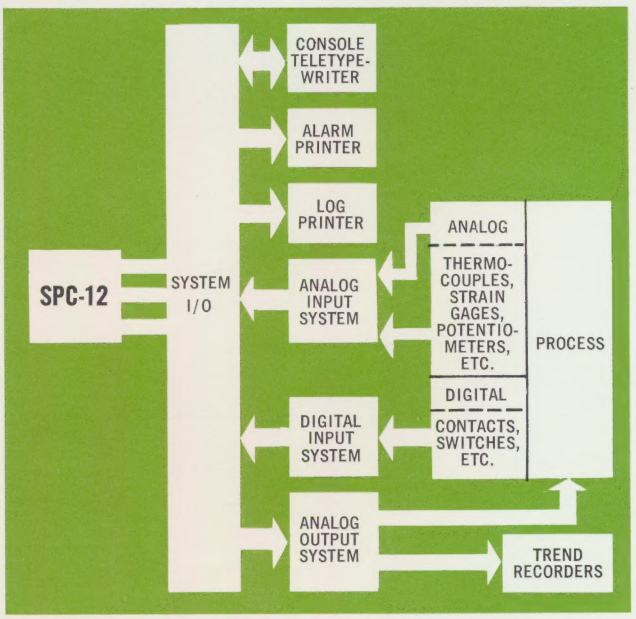


THE SPC-12 IN DATA ACQUISITION/PROCESS CONTROL

General Automation computers are field-proven in hundreds of data acquisition/process control applications. GA computer-based automation systems provide the basic process monitoring functions of analog and digital input scanning; conversion to engineering units of flow, temperature, pressure, etc.; digital smoothing; alarm limit comparison; alarm and return-to-normal message recording; trend recording; and periodic and demand logging of process variables.

The SPC-12 Automation Computer is the heart of the process monitoring system. Programs are loaded into the computer's core memory to define the systems operation.

High-speed and low-level analog input signals are scanned and converted. The converted, filtered analog value is then compared against process high/low limits and set appropriate alarm flags or a return-to-normal flag. All of these limits, flags, and control points are stored in the computer's core memory and, because they are variable, they can be set and reset by the operator as required. In addition to analog input signals, a digital scanner reads and stores the contact status. Status is compared to the desired status and any differences are flagged for alarm printout. Analog outputs are updated to trend recorders based upon the most recent scanned value. Logging functions are also variable, and may be determined and set by the operator as desired. Some of the operator variables are high and low limits, scan rate, status alarm conditions, trend up-date periods, log printout rate, etc.



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FEATURES

The SPC-12 is powerful. It can execute stored programs in excess of 230,000 instructions per second, and can input or output data in excess of 460,000 words per second. Its instruction repertoire minimizes core-memory storage requirements while processing real-time control programs efficiently. The processor is optimized for real-time control processing; it has registers than can be used as accumulators or index registers, a list processing command set, and General Automation's exclusive "shared command" technique to give memory up to 50% greater utility. Control function facilities are standard: relative-time clock, external priority interrupt, parallel I/O bus, and serial I/O channel. The standard computer includes a 4,096 by 8-bit word memory (expandable to 16,384 words) with a full cycle time of 2.16 usec. It provides a 12-bit parallel adder; six addressing modes; eight 12-bit hardware registers, including an accumulator and three index/accumulator registers; 52 basic commands; a processor-controlled priority interrupt system; a relative time clock; a console lock; and a teletypewriter interface.

The SPC-12 is easily interfaced. Minicontrollers are GA system interface units that provide system modularity and interface versatility. The functional, plug-in design eliminates excessive and redundant electronics, and permits economical system configuring, servicing, and expansion. Over 70 pre-engineered minicontrollers are available off-the-shelf, providing system flexibility in interfacing with mechanisms, devices, instruments, sensors, and peripherals.

The SPC-12 is versatile. With its one package enclosure, the SPC-12 offers great versatility in a wide variety of applications. The SPC-12 can be used to place stored intelligence into industrial machinery, collect and process data in hospitals and medical laboratories; concentrate, store, forward, switch, and separate data in communication systems; receive and generate data in display systems; count and control traffic; automate production and testing processes; and scan, log and alarm data in process control.

The SPC-12 is compatible. It can be easily added to an existing system with a minimum of cost and system downtime. It can also be used as today's basic automation system, while assuring easy addition of expansion or supervisory/management equipment as future needs arise. The SPC-12 is part of GA's growing family of compatible computer products in Distributed Computer Control. This concept provides a more functional and efficient method of manufacturing automation; it matches the size and capability of the computing system with the size and complexity of the application. Thus, each computer is priced commensurately with the level of work performed, offering maximum operation efficiency and profit returns with minimum expansion costs as well as minimum initial investment.

The SPC-12 is easily programmed. Every SPC-12 includes support software packages to assist system integration and to facilitate project completion. The programming aids — Subroutine Library, Hardware Test and Verify, BUS, CAS, etc. — are designed to minimize the time required to prepare functional programs. The optional real-time monitors, designed for application in communications, machine control, instrumentation and real-time control, can be applied requiring only programming of the unique functions of a specific application.

In addition, GA offers a wide selection of optional service-oriented and functional-application "Automate" programs. GA service programs permit the user to write, edit, debug, and implement his programs quickly and economically. GA "Automate" programs are general application programs with which programmers can create specialized software for a project with a minimum expenditure of time, money and manpower. A wide selection of off-the-shelf software programs are available from GA Technical Application Centers.

The SPC-12 is supported by a full range of automation services. As the "total solution" automation company, GA supports its entire hardware/software product line with a full range of technological services for successfully implementing your automation project. GA's staff of experienced, highly qualified automation experts provide professional aid for any phase of project analysis or implementation to complete turn-key project responsibility. These services include: applications analysis and consultation, system engineering, project management, applications programming, and user training. Computer warranty and installation and maintenance support is also available with each SPC-12 system. All of these services — plus a complete software library and processing center — are available economically and conveniently from GA Technical Application Centers.

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RELIABILITY

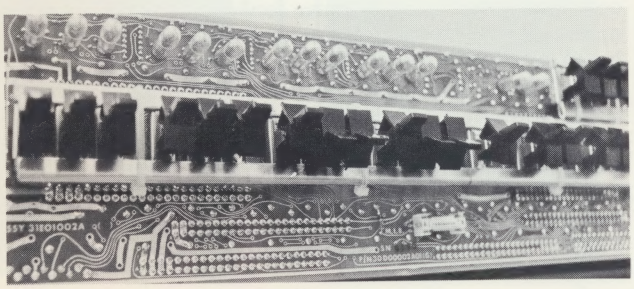
The high performance and long-life reliability of the SPC-12 is the result of GA's unique fourth-generation design, materials, and manufacturing and testing techniques. Fourth generation technology is used in all GA computer products, beginning at the critical design state with stringent "worse-case" criteria. Mass production, state-of-the-art techniques utilize small, medium and large scale integrated circuits with completely wire-free construction. The computer has no processor wires and has fewer components, fewer connectors and dissipates less power than any other full-scale general-purpose digital computer available commercially. All components and subsystems are subjected to 100% testing and inspection. Each SPC-12 is successfully operated in an environmental test chamber, followed by vibration testing and a prolonged burn-in period prior to shipment. This exhaustive testing eliminates defective components which have "infant mortality" tendencies. Fourth generation technology, then, provides the SPC-12 with exceptional margins for speed, temperature, power and noise to operate dependably in an industrial environment. With built-in automation fail-safe features, SPC-12 computers plug in, work, and keep on working. They work unattended, around the clock, in real-time industrial applications.

FAIL-SAFE FEATURES

In addition to the reliability designed and manufactured into the SPC-12, the SPC-12 has a number of unique features that make it more efficient for industrial control application. They include the Operations Monitor Alarm, System Safe Line, System Reset Line Priority Interrupt System, Power Failure Detection and Automatic Restart, and 24-volt Battery Input. These fail-safe features protect the computer system from the costly consequences, usually associated with power interruptions, power transients, component breakdown, programming bugs, or system shutdown. The fail-safe features give ultimate protection to operations and processes without the need for human surveillance.

Power Failure Detection and Automatic Restart (option)

The Power Failure Detection and Automatic Restart feature provides information to the operator whenever power has failed, and upon power restart can initialize the system. By monitoring the input power, an automatic and orderly shutdown is effected if power fails, preserving the contents of memory.



Operations Monitor Alarm

One of the prime criteria for computers in a control environment is that the computer must always be in control or inform the operator when something is not normal. The Operations Monitor Alarm (OMA) provides this capability. It alerts the operator of any abnormality, improper program sequencing, or previously undetected program bugs. It also provides an orderly halt to instruction execution.

Console Lock

The console is protected from random action of passerbys by a Console Lock deactivating the system console. Once locked, none of the console switches have any effect.

Battery Power

Where it is desirable to maintain system operation independent of the fluctuations or availability of common ac power, the Battery Power Adapter permits operations from a dc source such as a battery. Battery power would normally be maintained at peak output capability by a charge operating from the ac source. Should the ac source fail, the fully charged battery would permit continued operation for a number of hours.

MAINTAINABILITY

SPC-12 design constitutes a major breakthrough in computer maintainability. The SPC-12 is designed and constructed for on-site replacement capability. The computer contains only three printed circuit boards: master interconnect, memory, and processor. Any one of these boards can be replaced by a service person without computer maintenance training within five minutes. Test and Verify programs indicate which, if any, of the three is not functioning. All parts are completely interchangeable; even memory stacks with loaded programs can be interchanged. Each element — processor, memory, etc. — is independently tested and is not dependent upon any other element. This enables the use of any processor in any processor slot or any memory board in any memory slot; no adjustments are required once a replacement is made.

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SOFTWARE

Three standard program systems are provided with the computer: the Subroutine Library, Conversational Assembly System and the Basic Utility System. In addition a substantial library of real-time monitors, executive control systems, process control functional programs, utility routines, and I/O drivers are operational and maintained for SPC-12 applications. As the "total solution" automation company, GA also offers programming services and specialized software programs through regional Technical Application Centers.

CONVERSATIONAL ASSEMBLY SYSTEM (CAS)

A symbolic assembly program that minimizes the time required for assembling a program. It permits the programmer to recover errors on-line without having to restart the assembly process. The programmer can insert corrections from the keyboard during assembly. The assembler also provides the programmer with a means of entering linkage and mapping common data. Instructions, data, memory addresses, and address modifiers can be coded and entered in symbolic notation. Detailed information on CAS and BUS can be found in the SPC-12 Programming Manual.

BASIC UTILITY SYSTEM (BUS)

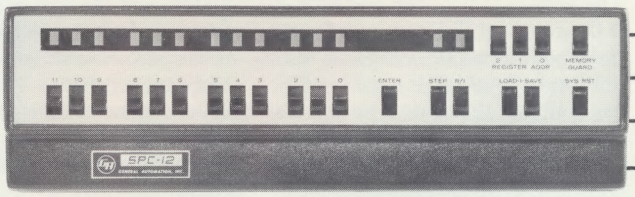
This system enables the programmer to trace through his program to correct errors, to enter and execute test cases, and to verify results. The system operates on line with a teletypewriter. Data can be input, instructions can be changed and small programs can be executed using the keyboard for input. The utility package contains routines for loading, punching, and listing programs as well as aids for debugging and updating programs. I/O programs for teletypewriters are also included in BUS.

SUBROUTINE LIBRARY

Includes a package of often-used utility programs, mathematical subroutines, hardware test and verification subsystem, and program tape preparation. Detailed information on the Test and Verification subsystem can be found in the SPC-12 System Integration and Verification Manual. Also provided is a library of mathematical subroutines which include multiple precision fixed-point addition, subtraction, multiplication, and division routines. Detailed descriptions of the mathematical subroutines can be found in the SPC-12 Program Description Manual. Optional I/O routines are available for such peripheral equipment as Teletype Model 33 or 35, send/receive sets, standard communication interfaces, discrete digital inputs and outputs, analog-to-digital and digital-to-analog conversion subsystems.

REAL TIME EXECUTIVE (RTX-12)

RTX-12 is an optional software package that provides supervisory control for real time programming on the SPC-12 computer. It is a modular software scheduling system that provides SPC-12 users the means to control a real-time process by initiating program execution based on interrupt activity (first priority) or system function (second priority) responses.



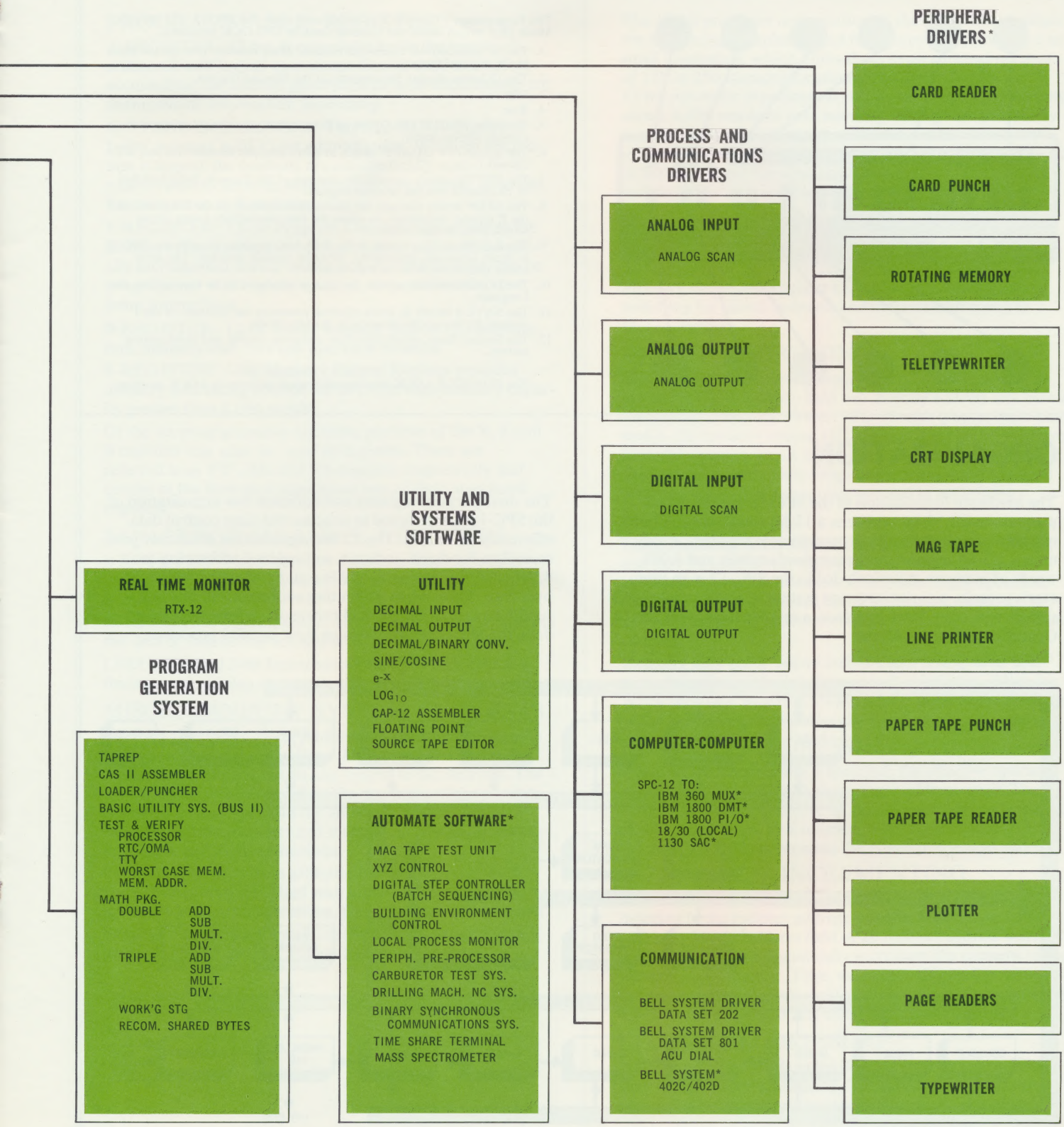
SPC-12 AUTOMATION COMPUTER

ASSEMBLER (CAP-12)

The CAP-12 is an optional I/O independent Assembler system that translates source programs written in symbolic language into SPC-12 machine language. It is a card-oriented system that simplifies program generation using card readers, high-speed paper tape readers and punches, and line printers. Also included in the family of CAP Assemblers is the CAP-1812; this program enables users to generate software for the SPC-12 on the powerful System 18/30 with a minimum of time and effort.

AUTOMATES

GA "Automates" are compatible with and run under the control of Real Time Executive service routines. They are optional general application programs designed to serve a broad range of processes (analog, digital, and communications I/O), and need only slight adaptation to suit a particular process within that range. With this approach, specialized software for a particular project can be created with a minimum expenditure of time, money and manpower. Typical GA "Automates" include Local Process Monitoring, Remote Process Monitoring, XYZ Controller, Digital Step Controller, and Binary Synchronous Communications Programs.



*Available only with associated hardware

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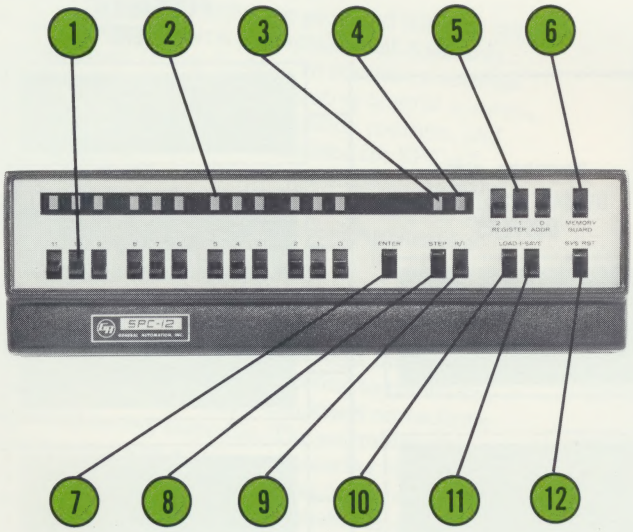
SYSTEM CONSOLE



The Programmer's Console is operable only when the SPC-12 is in the Idle Mode (R/I switch down and Console Lock in UNLOCK position).

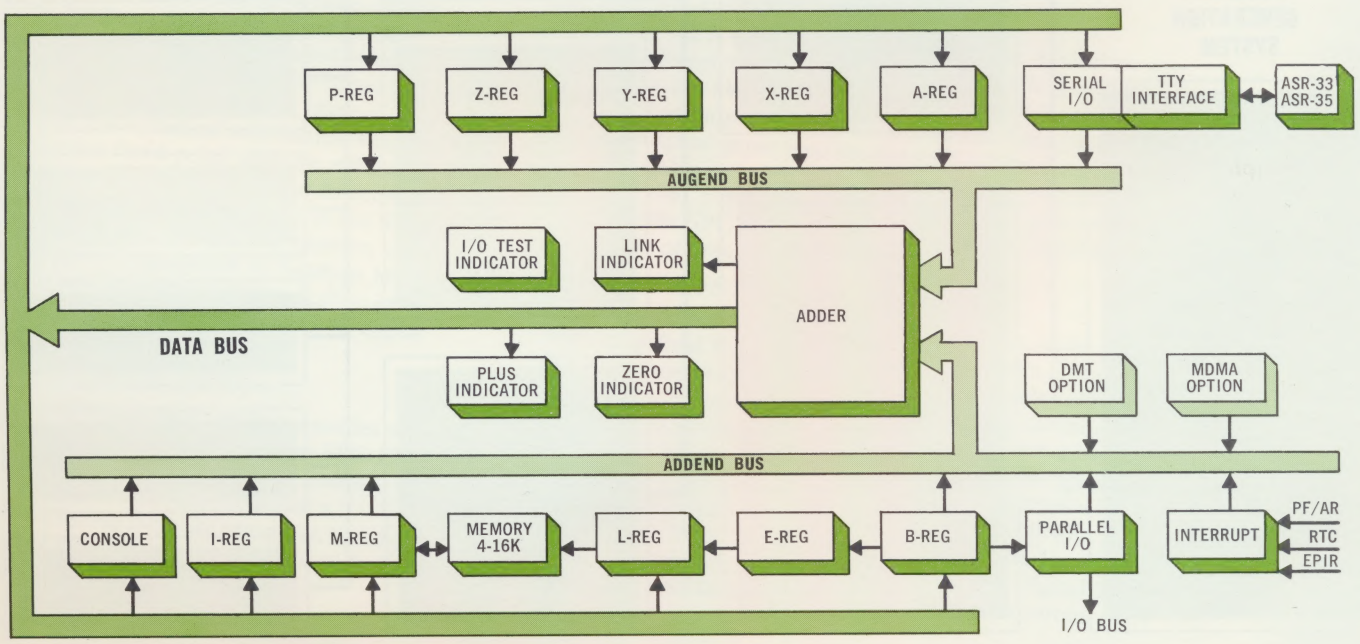
1. The 12 consecutively numbered Console Data switches provide for input to the selected register.
2. The 12 lamps display the contents of the selected register.
3. Idle
4. Run
5. The three REGISTER ADDR switches select one of eight registers for console display/entry.
6. The MEMORY GUARD switch in down position disables memory drive circuits.
7. The ENTER switch permits the contents of the Console Data Switches to be entered into the selected register.
8. The STEP switch executes the instruction currently in the I register, and the P register increments to select the next instruction. Lamp above switch is on in Idle Mode.
9. The R/I (Run/Idle) switch in the Run (up) position permits the SPC-12 to begin automatic sequencing. Disables console switches. The lamp above this switch is on in Run Mode.
10. The LOAD-I switch permits the data as displayed to be entered into the I register.
11. The SAVE-I switch in down position preserves the contents of the I register for repeated execution in the Idle Mode.
12. The System Reset switch initializes computer timing and input/output system.

The CONSOLE LOCK disables all console switches in LOCK position.

ORGANIZATION

The hardware organization of the SPC-12 consists of six programmable 12-bit registers, a 12-bit adder, three 12-bit transfer busses, three non-programmable registers, 4 indicators, a 3-bit memory address extend register and 4,096 words of memory. Also included in the SPC-12 is an operator's console, priority interrupt system, a 12-bit parallel I/O system with teleprinter interface, a relative time clock, and a Operations Monitor Alarm.

The dual-purpose registers and common bus organization of the SPC-12 are designed to process real-time control data efficiently and easily. The 12-bit organization efficiently processes data for direct, indirect, and indexed addressing to 4,096 words of memory, and is equally effective with 8-bit byte data. Thus, when generating addresses, the SPC-12 functions as a 12-bit parallel processor. When processing data, the SPC-12 operates as an 8-bit parallel processor.



REGISTERS

PROGRAMMABLE REGISTERS

A REGISTER: 12-bit Accumulator holds the results of arithmetic and logical operations. Can be used as a 12-bit accumulator for address generation or 8-bit accumulator for arithmetic or information processing.

X, Y, AND Z REGISTERS: Three 12-bit Accumulator/Index registers hold 12-bit address index. When an instruction is tagged, the contents are automatically added to address field to form an effective operand address. Also can function same as A register.

P-REGISTER: 12-bit Program Counter register holds the address of the instruction being executed and is automatically incremented during instruction execution. Also, can be programmed with register transfer, skip, arithmetic, or jump instructions.

B-REGISTER: 12-bit Buffer Register buffers I/O information, memory transfers and operands to adder.

E-REGISTER: 3-bit Memory Extend Register provides memory addressing control for SPC-12s with memory capacity greater than 4,096 words.

Of the six programmable registers, portions of the Y, Z and B registers can also be used as registers. These are referred to as YY-, ZZ- and BB-registers respectively and consist of the four most significant bits of their associated registers.

NON-PROGRAMMABLE REGISTERS

L REGISTER: 12-bit Memory Location Register which contains the address of data or instruction being addressed in memory.

M REGISTER: 8-bit Memory Data Register which contains the data or instruction fetched or stored in memory.

I REGISTER: 12-bit Instruction Register which contains the instruction being executed.

MISCELLANEOUS SYSTEM ELEMENTS

ADDER: performs 12-bit address arithmetic and 8-bit data arithmetic and logic operations. Data is received from the Addend and Augend busses and output to the data bus. The zero and plus indicators reflect the condition of the last data operation to transfer from the adder to the data bus. This includes register transfers and memory references as well as arithmetic and logical functions.

LINK: holds carry from arithmetic operations and bit O from shift operations. Used with logical or with multiple precision arithmetic operations. Can be tested, set, and reset.

Detailed information describing the SPC-12 organization is contained in the SPC-12 System Reference Manual.

ADDRESSING

The 12-bit processor organization of the SPC-12 overcomes the addressing complexity and handicaps generally found in small computers, which limits them to an addressing range of 128 or 256 memory locations. The SPC-12, with its 12-bit processor organization, allows the program to directly access 4,096 words of core memory. Along with this ability to address 4K of memory, the SPC-12 also has the ability to perform arithmetic functions on a 12-bit data word instead of 8-bits (normal for most small computers). The SPC-12 thus has the 12-bit arithmetic capabilities required when generating and operating on addresses, and the 8-bit arithmetic capabilities required when operating on data. The SPC-12 provides the economy of an 8-bit computer with the performance of a much larger machine. In addition, the Memory Extension Register (E register) permits mode switching for direct, indexed, and indirect addressing to 16,384 words.

DIRECT ADDRESSING

Memory Reference instructions have a 2-byte format. The low-order 12-bit address field will directly address any byte in a 4,096-byte memory. For an SPC-12 with greater than 4,096 words, the memory extend (E) register is set under program control to specify which memory mode is to be addressed. This eliminates the costly programming overhead required when extensive paging are incorporated in addressing.

INDEXING

Three hardware index registers are provided in the SPC-12 and may be selected for use by those instructions whose address fields may be indexed. When indexing is specified, the contents of the selected index register are added to the address field of the instruction to form the effective operand address.

Indexing may occur before indirect addressing, after indirect addressing, or both before and after indirect addressing. When specified, indexing always occurs prior to the forming of the indirect address and/or the effective operand address.

INDIRECT ADDRESSING

When indirect addressing is specified, the effective operand address is developed from the indirect address word. The 12-bit operand address may be the effective operand address or may be modified by a selected index register, and then the modified address becomes the effective operand address.

AUTO-INDEX INCREMENTING

When indirect addressing is used, it is possible to specify indexing in the indirect address word. In addition to being able to index the address field of an indirect address word, it is also possible to automatically increment the contents of the selected index register. Thus, when indexing and incrementing are specified, the selected index register is incremented by 1 before the forming of the effective operand address.

LITERAL ADDRESSING

Some of the commands in the SPC-12 instruction repertoire may specify literal addressing. This feature selects as the operand the contents of the memory location immediately following the location of the current instruction.

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INSTRUCTIONS

The powerful, but versatile, instruction capabilities of the SPC-12 makes that automation computer ideal for control applications such as process control and manufacturing automation. The SPC-12 provides increased instruction efficiency, such as the Skip instruction which has a variable range; the Logical instructions which include "AND", "OR" and an "EXCLUSIVE OR"; and arithmetic instructions which include "ADD" as well as "SUBTRACT". A group of register transfer instructions provide the capability to transfer contents of one 12-bit register to another 12-bit register and to perform arithmetic operations on the data during transfer.

Also unique with the SPC-12 is Augmented Memory addressing instructions. This enables loading and storing of data as well as arithmetic functions from memory with direct or indirect addressing, pre- or post-indexing, or any combination of these such as pre-index, indirect, and post-indexing with automatic incrementing of the index register. This feature also enables the SPC-12 to manipulate lists and tables efficiently, and to perform a wide variety of operations with a minimal number of instructions.

Another important feature of the SPC-12 is the "Shared Command" technique. This technique overcomes one of the major limitations of small digital computers; the requirement of two memory locations to store a single instruction: the Shared Command technique enables the SPC-12 to completely specify full instruction in only one byte of in-line coding instead of the normally-required two, and locating the other byte in a common pool, accessible by the same instruction in other locations. Thus, if an instruction is used throughout a program 100 times, the SPC-12 can store them in 101 bytes of memory instead of 200 bytes. This represents a typical core savings of 30 to 35%, and makes possible programs which might require 5K of memory to be executed with 4K of core, at no increase of execution time.

MEMORY REFERENCE

This class contains the basic instructions of Load B from memory, Store B in memory, Load B extended (12 bits of data), and Jump Unconditionally. Each of these instructions provides direct addressing to 4,096 locations. Load B and Store B can also be indexed by X reg.

SKIP

This class contains one basic instruction which can be coded to skip 0, 2, 4, 6 locations when the coded Condition is satisfied.

Skip conditions:	I/O Test False	I/O Test True
	Link Reset	Link Set
	Adder Result Non Zero	Adder Result Zero
	Adder Result Minus	Adder Result Plus

ARITHMETIC/LOGICAL

The Arithmetic/Logical Class contains instructions to Load, Clear, Add, Subtract, OR, AND or EXCLUSIVE OR the A, X, Y, Z, or P registers with the register B, or a literal addressed operand.

Arithmetic/Logical (A/L) instructions have 2 bytes, where the second byte can be stored in P+1 (the next location in memory) as two sequential bytes or in a shared pool of 16 locations, starting at location 20_8. The common pool is termed "Shared", since other A/L instructions can address and execute the same second byte. The term "immediate" signifies that the second byte of the instruction is dedicated and will be fetched from location P+1.

REGISTER TRANSFER

Register Transfer (RT) contains four basic instructions that can be coded to transfer a source register to a destination register. The transfer can be coded to Add Link, Increment, Decrement, or not change the data transferred. RT instructions have 2 bytes, where the second byte can be stored in P+1 (the next location in memory) as two sequential bytes or in a shared pool of 16 locations, starting at 40_8 requiring only one byte of coding.

CONTROL/SHIFT/I/O

This class contains Shift, Set/Reset Link, Transfer BB to B, Serial input/output, Parallel input/output, Transfer B to Memory Extend Register, and Interrupt control instructions. Instructions have 2 bytes, where the second byte can be stored in P+1 (the next location in memory) as two sequential bytes or in a shared pool of 16 locations, starting at 60_8 requiring only one byte of coding.

AUGMENTED MEMORY

This class contains four basic instructions for Storing and Clearing registers, Storing registers, Loading registers, and Adding from memory to registers. The instructions can specify indexing by X, Y, or Z and indirect addressing. Instructions have 2 bytes, where the second byte can be stored in P+1 as two sequential bytes or in a shared pool of 16 locations, starting at 100_8 using only one byte of in-line coding.

For detailed information on Instruction Classes, write for the SPC-12 Reference Manual.

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SPECIFICATIONS

TYPE
A digital, automation computer. Single address, 12-bit parallel processor.

MEMORY
Random access. Wide temperature ferrite magnetic core memory storage. 4,096 words of 8-bit memory (expandable to 16,384 words). Memory cycle time of 2.16 μsec; access time, 600 nsec.

ADDRESSING
Six modes: Direct addressing to 4,096 locations; Literal addressing; Indexing; Indirect; Auto Index Incrementing; Extended memory addressing.

ARITHMETIC
Parallel. Binary, fixed point, twos complement, 8 and 12-bit.

INSTRUCTIONS
Single and double word instructions. 52 basic instructions within six classes: Memory Reference; Skip; Arithmetic/Logical; Register Transfer; Control, Shift, I/O; and Augmented Memory.

SPEED
Instruction Execute Times

Add/subtract registers	4.32 μsec
Load/store from/to memory	6.48 μsec
Add memory	6.48 μsec
Input I/O bus to B register	4.32 μsec
Output B register to I/O bus	4.32 μsec

INPUT/OUTPUT
12-bit parallel I/O bus. Serial I/O bus. Automatic priority interrupt, relative-time clock; optional fail safe features direct memory transfer, and MDMA port.

SOFTWARE
Software includes: Conversational Assembly System, Basic Utility System, Subroutine Library, Hardware Test and Verify Programs, and optional generalized real-time monitors, applied programming services, and application software.

OPTIONS
Expansion to 16K memory. Read-only memory. Power fail detection and automatic restart. Direct memory transfer channel and control unit. Multiple direct memory access port. Priority interrupt expander unit. Over 70 minicontroller interface units. Mounting hardware. Battery power adapter (24 vdc input). Teletypewriter. Peripheral equipment. Application, programming and engineering services. Real-time monitors. Hardware optimization system engineering for minimum recurring cost systems.

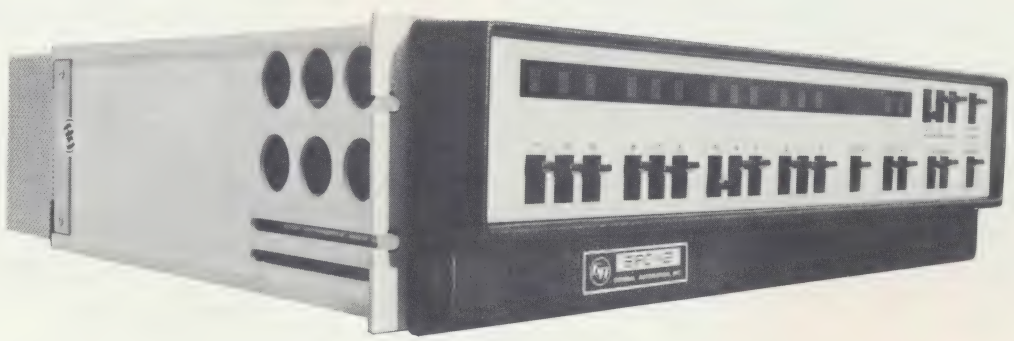
DIMENSIONS,
including power supply and cooling: Height 5¼ inches. Width 17½ inches. Depth 23 inches.

WEIGHT,
including power supply and cooling: 29 lbs.

TEMPERATURE,
Operable: 0 to 50° C.

HUMIDITY,
Operable: 90% relative.

POWER
115 volts ac ±10%. Single phase. Frequency of 47 to 63 hz. 24 vdc power supply and 230 vac power optional.



12

I/O SYSTEMS

PARALLEL I/O SYSTEM

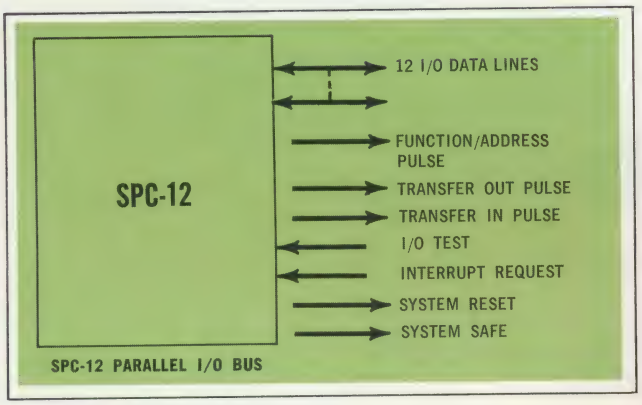
The parallel input/output system of the SPC-12 minimizes the need for external hardware. Three instructions of the SPC-12 provide a maximum amount of control of the I/O System without sacrifice of speed or efficiency. These three instructions address the device and the data transfers:

(1) output function address from B register,
(2) input data to the B register, and
(3) output data from the B register.

The execution of an I/O program does not interfere with information being processed in the accumulators. All data and address transfers take place through the B register, a 12-bit buffer register. The arithmetic characteristics of the I/O data can be tested prior to storage for further manipulation.

The parallel I/O system provides flexibility through a single set of data and control lines to interface readily to a wide variety of external equipments simultaneously. The 12-bit data bus of the I/O permits efficient handling of 8, 12, 16, and 24-bit data transfers. The design permits extended use of the I/O channel in that it can be separated into an input channel and an output channel to operate as two unidirectional busses.

The SPC-12 never needs modification for adding new peripherals or interfaces; such expansions can be easily achieved in the field. New devices are added by simply connecting the I/O bus from the last to the new device.



SERIAL I/O SYSTEM

The serial input/output system is a unique data transfer channel that permits the input and output of serial data. Operation of the serial I/O is independent of the parallel I/O system.

The serial I/O bus is a 3-wire, full duplex, 48 vdc, 20 ma, telegraph grade line. Typically connected to a Teletype ASR 33 or 35, it permits operation up to 2000 feet away. Two instructions — input and output of serial data to and from the A, X, Y, or Z registers — provide the SPC-12 complete control of the serial I/O system.

INTERRUPTS

An important requirement for computers in real-time applications is that the processor must always be in control. Thus, whenever a device external to the processor requires the services of the processor, it is accomplished at the processor's convenience rather than the device's. Normally, this means that interrupts must be disabled when the processor is performing tasks where interruptions are not allowed; then, enabling interrupts from external devices when the processor's task is completed and at the processor's convenience. The period of time that the interrupt is disabled is called "worst case interrupt response time"; it is the longest period of time that a device will have to wait in order to have an interrupt processed by the computer. When the interrupt does occur, the processor must save registers as part of the interrupt routine, so that when the interrupt servicing is complete, the processor returns to continue the interrupted routine. The SPC-12 solves this problem by opening a window when interrupts are enabled; at all other times, interrupts will be disabled. These windows are placed throughout the program in accordance with the system's response requirements. Enabling of interrupts can also be accomplished in such a manner that the requirement of saving registers is eliminated. This unique approach in the SPC-12 interrupt system improves processing efficiencies and provides greater system flexibility while allowing the processor to maintain control of its process or device at all times.

INTERRUPT SYSTEM

This system provides the abil ty to interrupt program sequencing to service requests from external equipment, automatic restart, and the relative-time clock. The external equipment interrupts are serviced over the interrupt request line of the parallel I/O system. The interrupt request line can service numerous external devices where the service priorities are established under program control. Interrupt priorities can also be established by hardware by adding interrupt expander units. Each unit provides the ability to service eight interrupt lines, with priority determination, address generation and arm/disarm facilities for each level. When an interrupt is acknowledged, the contents of the program counter are saved, and program control is transferred to a unique and dedicated location.

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DIRECT MEMORY TRANSFER OPTION (DMT)

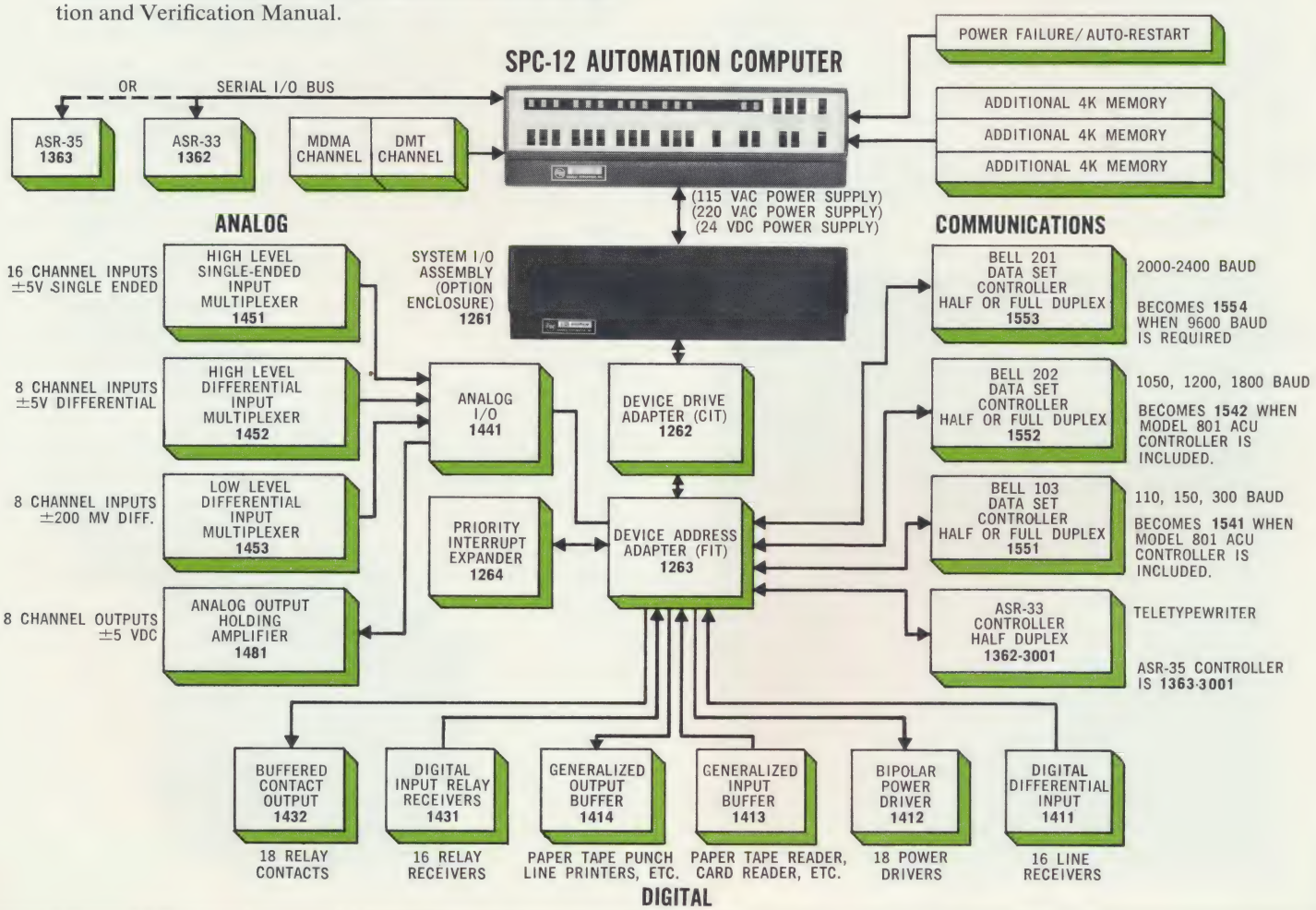
The DMT option provides the capability of direct access to the main memory without program intervention. The DMT operates on a memory cycle-steal principle. Whenever an external device requests a memory cycle, for input or output, the program is interrupted at the end of a command for one or more memory cycles that are used by the DMT. Then control of the computer is returned to the program. The DMT provides for input/output rates in excess of 460,000 bytes per second under hardware control. The DMT addressing control is fully buffered so that sequential block transfers can occur without a "setup" interval occurring between transfers. External devices can control the interleave and burst mode, direction of transfer, and activation of transfer. In the interleave mode, transfers can occur at any rate up to 100,000 bytes per second. Each transfer takes only one memory cycle from the SPC-12. Rates between 100,000 and 460,000 bytes per second can be provided in the burst mode. The processor is stalled during the burst mode. Additional information can be found in the System Integration and Verification Manual.

MULTIPLE DIRECT MEMORY ACCESS OPTION (MDMA)

The SPC-12 MDMA port is a high-speed (460,000 bytes/sec) data transfer vehicle designed to solve the intricate timing problems associated with data transfers, and to let the system philosophy and implementation be at the burden of the external device controller. This provides the means to handle any system complexity problem at the controller and permits the MDMA port to remain relatively general.

A priority clock synchronizes multiple controllers on the MDMA bus. Controllers can be tied on the party-line MDMA bus with the maximum number being defined by the system throughout and worse-case response time.

Fourteen address/data lines are time-shared between eight lines for data and all 14 lines for address. In addition, nine control lines are provided to implement the intialization requirements of the system. Additional information can be found in the System Integration and Verification Manual.



14

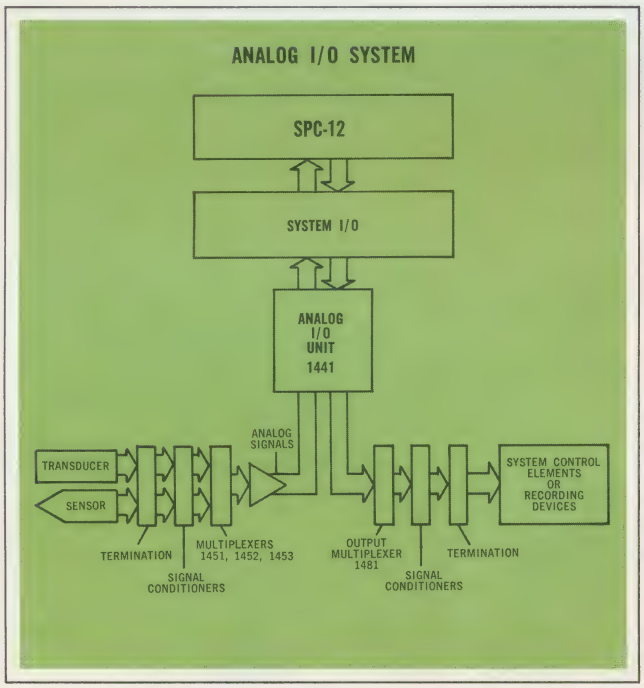
MINICONTROLLERS

Minicontrollers are pre-engineered GA system interface units that enable multiple technologies to be combined in one computer subsystem. Their functional, plug-in design provides system modularity and interface versatility, eliminates redundant electronics, and permits quick, economical system configuring, expansion, and servicing. Minicontrollers make interfacing easy and economical.

A wide selection of off-the-shelf minicontroller units are available for interfacing and controlling instruments, sensors, mechanisms, devices, communications data sets, displays, keyboards, and a wide range of GA peripherals. By providing compatibility with existing customer device designs, design time and costs for implementation are substantially reduced. Field-proven integrated circuits throughout the advance-state design provide extremely high reliability. Minicontrollers can be housed in a 21-unit common enclosure with built-in power supply, cooling unit, and plug-in connectors.

ANALOG I/O

The Analog I/O System provides the wide range of capabilities required for the SPC-12 to communicate with analog devices. The analog I/O unit performs both digital-to-analog and analog-to-digital conversions. This analog I/O capability enables the SPC-12 to be readily interfaced to such devices as thermocouples, strain gauges, pressure transducers, potentiometers and other analog input devices. At the same time, it will also drive system control functions, recording devices and other systems elements requiring analog outputs. These features make the SPC-12 easy to use in an analog environment.



1441 ANALOG I/O UNIT (AIO)

The 1441 Analog I/O performs both analog-to-digital and digital-to-analog conversions. It is used with the 1451, 1452 and 1453 Analog Input Multiplexers and the 1481 Analog Output Holding Amplifier to provide the system with an increased range of capabilities. When operating in the input mode, the analog I/O unit accepts a bipolar 5 volt analog signal from an analog input multiplexer and converts it to a 12-bit, 2's complemental digital value in 40 microseconds, providing high resolution coupled with very fast conversion time.

Up to 80 analog input multiplexers can be connected to one analog I/O unit; up to 640 discrete analog signals can be converted by one analog I/O unit. The analog I/O unit can also connect up to 10 Output Holding Amplifiers to provide up to 80 analog control lines.

ANALOG INPUT

Three analog input multiplexers provide a wide variety of systems capability to satisfy a broad range of requirements. Detailed information on analog input multiplexers can be found in the GA Minicontroller Brochure.

1451 HIGH LEVEL SINGLE-ENDED INPUT MULTIPLEXER (SEM)

The 1451 can interface sixteen channels of bipolar ±5 volt analog input with the 1441 analog I/O unit. It provides multiplexing input capability for single-ended analog signals and is suited for applications where ground potentials are small with respect to the signal voltages. Each channel may be randomly addressed and switched with high speed, solid-state field effect transistors for contactless input switching.

1452 HIGH-LEVEL DIFFERENTIAL INPUT MULTIPLEXER (HLM)

The 1452 provides analog input capability for 8 channels, which may be randomly addressed and switched with high-speed field effect transistors to the 1441 Analog I/O unit. Input signal range is ± 5 volts for use in applications where a significant common mode voltage is present.

1453 LOW-LEVEL DIFFERENTIAL INPUT MULTIPLEXER (LLM)

The 1453 provides analog input capability for 8 channels which may be randomly addressed and switched with high-speed field effect transistors to the 1441 Analog I/O unit. Input signal range is ± 200 millivolts for use in applications where a significant common mode voltage is present.

ANALOG INPUT SIGNAL CONDITIONERS

Used when standard input ranges must be modified to meet specific external circuit requirements. Obtains one or more of the following conditioning features when selectively applied to analog input points.

- High-frequency noise rejection
- AC power line and harmonics rejection
- Curent-to-voltage mode conversion
- Voltage attenuation
- Thermocouple-to-copper conductor interfacing with cold-reference-junction measurement features.
- Special bridge circuit interfaces (Strain gauges, Galvometers, etc.)

ANALOG OUTPUT

An Analog Output Holding Amplifier is available for use with the 1441 Analog I/O Unit at the same time as the Analog Input Multiplexers.

1481 ANALOG OUTPUT HOLDING AMPLIFIER (OHA)

Each 1481 provides 8 channels of analog output at a range of ± 5 volts. A digital value is supplied to the 1441 Analog I/O Unit by the SPC-12. The 1441 converts this digital value to analog. It then supplies this voltage to the 1481 Analog Output Holding Amplifier which gates it into the selected output channel. The output channel maintains the voltage to within 5 mv per second at 25°C. Each output channel is fully buffered and has a low output impedance to make its output voltage almost independent of its load.

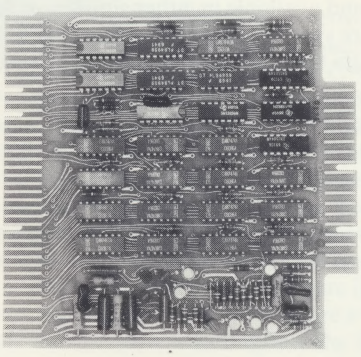
ANALOG OUTPUT SIGNAL CONDITIONERS

Used when standard output ranges must be modified to meet specific external circuit requirements. Typically, the signal modifications include the following:

- Voltage attenuation
- Zero offset
- Voltage amplification
- Split range outputs

ANALOG OUTPUT TERMINATION MODULES

Provides screw-down terminals or rugged multi-point cable connectors for terminating field wiring to customer equipment. Can be mounted to customer housing or in GA 1900 racks and enclosures.



DIGITAL INPUT

The Digital Input Subsystem permits computer-directed real-time acquisition of digital information in 4, 8, 12 or 16 bit parallel groups. The data word may consist of fields of binary-coded-decimals, binary, discrete bits, or any other pattern. Subsystem modules include group select and control logic, adapter unit, signal conditioners, and termination.

1411 DIGITAL DIFFERENTIAL INPUT UNIT (DDI)

Provides a digital input signal interface to the processor for high speed applications or for applications requiring high-level electrical isolation. Can be used as an input unit for pulse type or dc signals, as an interface with remote equipment having low-power logic signal outputs, or as a line receiver. Each DDI module has 16 digital input circuits arranged in one group of 8 and two groups of 4. These groups can be wired to meet the users requirements. Threshold voltage is selectable to meet user requirements (five ranges between ±7.5 volts and −7.5 volts).

1431 DIGITAL INPUT RELAY RECEIVER (IRR)

The 1431 provides a digital input signal interface to the processor for applications that require electrical isolation. Electrical isolation of processor input signals is provided through the use of relay coil input circuits. The low power requirements of the input relay coils make the unit suitable in applications having either hard contact of electronic signal sources.

Each IRR has 16 digital input circuits, arranged in one group of 8 and two groups of 4. Relay coil input circuits provide complete electrical isolation between input and output. Built-in arc suppression diodes protect external drivers from inductive voltage transients of relay coils.

1413 GENERALIZED INPUT BUFFER (GIB)

General-purpose input device used for parallel data communication between equipment using TTL-compatible circuitry. By wiring at the card connectors, GIB functions available include input data buffers, data buffer flags, strobes, line driver and card addressing. Options allow selection of termination resistors or open collectors on the buffer output gates. Data to the GIB can be supplied from a 5V or 6V source. A system restart input resets the data buffer flags on system startup and automatic restart. Can be used as a peripheral device input controller with paper tape readers, card readers, and other medium-speed peripherals.

DIGITAL INPUT SIGNAL CONDITIONING

Used when the standard input ranges must be modified to meet specific external circuit requirements.

DIGITAL INPUT TERMINATION MODULES

Permits field wiring connections to either screw-down terminals or multi-point cable connectors. Can be mounted in customer housing or in GA 1900 racks and enclosures.

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DIGITAL OUTPUT

Digital Output Subsystem permits direct transmission of digital control signals from the computer to customer equipment under program control. Subsystem modules include adapter units, termination, data register and output units.

1412 BUFFERED BIPOLAR POWER DRIVER (BPD)

Provides the interface between the processor and peripheral and control equipment requiring high-speed (above 1 kHz) driver signals from the processor. Suited for applications that require electrical isolation with nominal common mode voltage rejection and for use as a relay driver, lamp driver, or line driver.

Each BPD has 18 output drivers, arranged in one group of 8 and two groups of 4; plus two drivers with independent gating for sending control or data exchange signals to external equipment. Each output driver has its own buffer storage for maintained signal output. Dual built-in control logic allows independent gating information into each buffer.

1432 BUFFERED CONTACT OUTPUT (BCO)

Provides the interface between the processor and peripheral of control equipment requiring electrically isolated drive signals from the processor. For applications requiring high common mode voltage capabilities with moderate (2ms) operation time and for controlling electromechanical equipment, lamps, annunciators, or in driving long lines.

The 18 outputs of each BCO are arranged in one group of 8 or two groups of 4; plus two outputs with independent gating for sending control or data-exchange signals to external equipment. Each contact output has its own buffered storage for maintained signal output. Dual Built-in control logic allows independent gating of information into each buffer. Fast-operating, long life rhodium-gold contacts normally provide over 100 million error-free operations when used at 500 ma. 25 V dc.

1414 GENERALIZED OUTPUT BUFFER (GOB)

General-purpose output device used for parallel data communications between equipment using TTL-compatible circuitry. By wiring at the card connectors, GOB functions available include output data buffers, data buffer flags, strobes, line receivers, and card addressing. Options allow selection of output drive current on input data high or low, and selection of open collector or termination resistors on the output. A system restart input resets the data buffer flags on system startup and automatic restart. Can be used as a peripheral controller with devices as printers, card punches, paper tape punches, etc.

DIGITAL OUTPUT TERMINATION

Provides screw-down terminals or rugged multi-point cable connectors for terminating field wiring to customer equipment. Can be mounted in customer housing or in GA 1900 racks and enclosures.

COMMUNICATIONS I/O

GA communications I/O units interface the computer to data transmission devices. These units are available for synchronous or asynchronous modes of operation, half or full duplex, and in a wide variety of data rates.

1551 BELL SYSTEM 103 DATA SET CONTROLLER (DS103)

Bell System 103 Data Set Controller provides a buffered interface between the SPC-12 processor and a Bell System Model 103 Data Set. Includes a serial-to-parallel/parallel-to-serial converter and a Bell System Interface. Half or full duplex; 110, 150 or 300 baud operation.

1541 BELL SYSTEM 103/801 DATA SET AND AUTOMATIC CALLING UNIT (DS103/801)

Provides a buffered interface between the SPC-12 processor and Bell System Model 103 Data Set with Model 801 Data Auxiliary Set (Automatic Calling Unit). Includes a serial-to-parallel/parallel-to-serial converter and a Bell System Interface. Half or full duplex; 110, 150 or 300 baud operation.

1552 BELL SYSTEM '202 DATA SET CONTROLLER (DS202)

Provides a buffered interface between the SPC-12 processor and a Bell System Model 202 Data Set. Includes a serial-to-parallel/parallel-to-serial converter and a Bell System Interface. Half or full duplex; 1050, 1200, or 1800 baud operation.

1542 BELL SYSTEM 202/801 DATA SET AND AUTOMATIC CALLING UNIT CONTROLLER (DS202/801)

Provides a buffered interface between the SPC-12 processor and a Bell System Model 202 Data Set with Model 801. Data Auxiliary Set (Automatic Calling Unit). Includes a serial-to-parallel/parallel-to-serial converter and Bell System Interface. Full duplex 1050, 1200, or 1800 baud operation.

1553 BELL SYSTEM 201 DATA SET CONTROLLER (DS201)

Half or full duplex synchronous operation. Includes a serial-to-parallel/parallel-to-serial converter and Bell System Interface. Operates up to 2400 baud, speed determined by modem clock.

1554 BELL SYSTEM 201 DATA SET ADAPTER (DB201)

Provides for the connection to Data Sets with synchronous transmitting capabilities of up to 9600 bps. Controller is double buffered and available in either simplex or full duplex. Includes hardware sync character detection and Bell Model 201 interface. Data transfer rate is determined by the clock of the Data Set.

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The GA Automation Products Division (APD) manufactures a comprehensive line of compatible, computer-based automation equipment. All GA products are designed around a modular-application theory, and may be used independently or as a total system, depending upon the size of the application. System interfacing, maintenance, and/or expansion is further simplified with wire-free, large-board construction and part interchangeability. Field expansion can be implemented without interrupting existing computerized operations. The GA line of supervisory systems, worker computers, and plug-in, pre-engineered mini-controllers excel in high performance-versus-cost, quality, reliability, compact packaging, and hardware/software compatibility.

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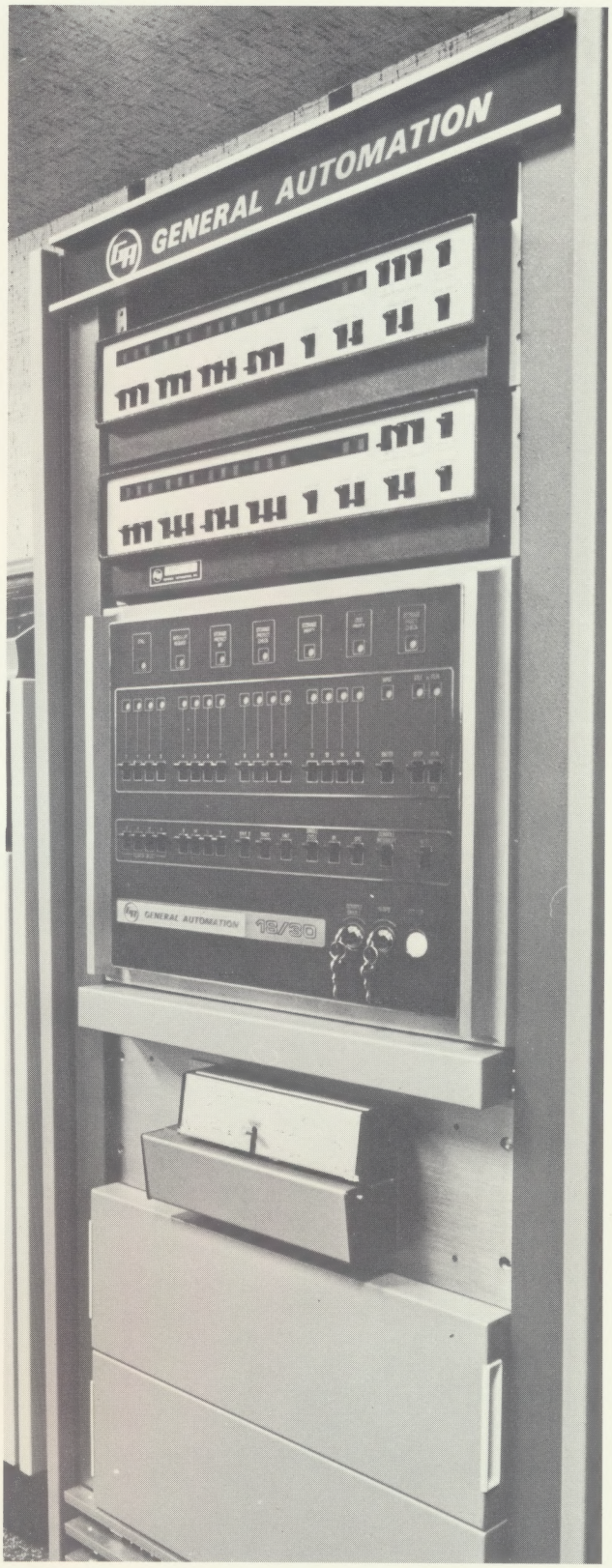

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